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U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

2.5.2 VIBRATORY GROUND MOTION

REVIEW RESPONSIBILITIES

Primary - Civil Engineering and Geosciences Branch (ECGB)

Secondary - None

I. AREAS OF REVIEW

The Civil Engineering and Geosciences Branch review covers the seismological, geological, geophysical, and geotechnical investigations carried out to determine the Safe Shutdown Earthquake ground motion (SSE) for the site. The SSE represents the design earthquake ground motion at the site and is the vibratory ground motion for which certain structures, systems, and components are designed to remain functional. The SSE is based upon a detailed evaluation of earthquake potential, taking into account regional and local geology, Quaternary tectonics, seismicity, and specific geotechnical characteristics of the site's subsurface material. The SSE is defined as the free-field horizontal and vertical ground response spectra at the plant site.

The principal regulation used by the staff in determining the scope and adequacy of the submitted seismologic and geologic information and attendant procedures and analyses is 10 CFR 100.23 (Ref. 1). Additional information (regulations, regulatory guides, and reports) is provided in References 2 through 9.

Guidance on seismological and geological investigations is provided in Regulatory Guide 1.165, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion" (Ref. 9). These investigations describe the seismicity of the site region and the correlation of earthquake activity with seismic sources. Seismic sources are identified and characterized, including the rates of occurrence of earthquakes associated with each seismic source. Seismic sources that have any part within 320 km (200 miles) of the site must be identified. More distant sources that have a potential for earthquakes large enough to affect the site must also be identified. Seismic sources can be capable tectonic sources or seismogenic sources; a seismotectonic province is a type of seismogenic source.

Specific areas of review include seismicity (Subsection 2.5.2.1), geologic and tectonic characteristics of the site and region (Subsection 2.5.2.2), correlation of earthquake activity with seismic sources (Subsection 2.5.2.3), probabilistic seismic hazard analysis and controlling earthquakes (Subsection 2.5.2.4), seismic wave transmission characteristics of the site (Subsection 2.5.2.5), and safe shutdown earthquake ground motion (Subsection 2.5.2.6).

The geotechnical engineering aspects of the site and the models and methods employed in the analysis of soil and foundation response to the ground motion environment are reviewed under Standard Review Plan (SRP) Section 2.5.4. The results of the geosciences review are used in SRP Sections 3.7.1 and 3.7.2.

II. <u>ACCEPTANCE CRITERIA</u>

The applicable regulations (Refs. 1, 2, and 3) and regulatory guides (Refs. 4, 5, 6, and 9) and basic acceptance criteria pertinent to the areas of this section of the Standard Review Plan are:

1. <u>10 CFR Part 100, "Reactor Site Criteria."</u> This part of the NRC's regulations describes general criteria that guide the evaluation of the suitability of proposed sites for nuclear power and test reactors (Ref. 3).

   <u>Section 100.23, "Geologic and Seismic Siting Factors," of 10 CFR Part 100</u>. This section of Part 100 requires the applicant to determine the SSE and its uncertainty, the potential for surface tectonic and nontectonic deformations, the design bases for seismically induced floods and water waves, and other design conditions (Ref. 1).

2. <u>General Design Criterion (GDC) 2, "Design Bases for Protection Against Natural Phenomena," in Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50</u>. This criterion requires that the structures, systems, and components important to safety be designed to withstand the effects of earthquakes, tsunamis, and seiches without loss of capability to perform their safety functions (Ref. 2).

3. <u>Regulatory Guide 1.132, "Site Investigations for Foundations of Nuclear Power Plants."</u> This guide describes programs of site investigations related to geotechnical aspects that would normally meet the needs for evaluating the safety of the site from the standpoint of the performance of foundations and earthworks under anticipated loading conditions, including earthquakes. It provides general guidance and recommendations for developing site-specific investigation programs as well as specific guidance for conducting subsurface investigations, such as borings and sampling (Ref. 4).

4. Regulatory Guide 4.7, "General Site Suitability Criteria for Nuclear Power Stations." This guide discusses the major site characteristics related to public health and safety that the staff considers in determining the suitability of sites for nuclear power stations (Ref. 5).

5. Regulatory Guide 1.60, "Design Response Spectra for Seismic Design of Nuclear Power Plants (Ref. 6)." Smoothed response spectra are generally used for design purposes -- for example, a standard spectral shape that has been used in the past is presented in Regulatory Guide 1.60. These smoothed spectra are still acceptable when the smoothed design spectra compare favorably with site-specific response spectra derived from the ground motion estimation procedures discussed in Subsection 2.5.2.6.

6. Regulatory Guide 1.165, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion" (Ref. 9). This guide describes acceptable methods to: (1) conduct geological, seismological, and geophysical investigations of the site and region around the site, (2) identify and characterize seismic sources, (3) perform PSHA, and (4) determine the SSE for the site (see SRP Section 2.5.2.6).

The principal geologic and seismic consideration for site suitability and geologic and seismic design bases are given in 10 CFR 100.23. Regulatory Guide 1.165 (Ref. 9) provides more detailed guidance on investigations and application of probabilistic seismic hazard analysis (PSHA). The seismic design bases are predicated on a reasonable, conservative determination of the SSE. The SSE is based on consideration of the regional and local geology and seismology and on the characteristics of the subsurface materials at the site. No comprehensive definitive rules can be promulgated regarding the investigations needed to establish the seismic design bases; the requirements vary from site to site.

2.5.2.1 Seismicity. To meet the requirements in Reference 1, this subsection is accepted when the complete historical record of earthquakes in the region is listed and when all available parameters are given for each earthquake in the historical record. The listing should include all earthquakes having Modified Mercalli Intensity (MMI) greater than or equal to IV or magnitude greater than or equal to 3.0 that have been reported within 320 km (200 miles) of the site. Large earthquakes outside of this area that would impact the SSE, should be reported. A regional-scale map should be presented showing all listed earthquake epicenters and should be supplemented by a larger-scale map showing earthquake epicenters of events within 80 km (50 miles) of the site. The following information concerning each earthquake is required whenever it is available: epicenter coordinates, depth of focus, date, origin time, highest intensity, magnitude, seismic moment, source mechanism, source dimensions, distance from the site, and any strong-motion recordings (sources from which the information was obtained should be identified). All magnitude designations such as m_b, M_L, M_s, M_w should be identified. In the Central and Eastern United States (CEUS), relatively little information is available on magnitudes for historic earthquakes which are reported but for which there are no instrumental recordings; hence, it may be appropriate to rely on intensity observations (descriptions of earthquake effects) or the dimensions of the area in which the event was felt to estimate magnitudes of historic events (e.g., Refs. 10 and 11). In addition, any reported earthquake-induced geologic failure, such as liquefaction (including paleoseismic evidence of large prehistoric earthquakes), landsliding, landspreading, and lurching, should be described completely, including the estimated level of strong motion that induced failure and the physical properties of the materials. The completeness of the earthquake history of the region is determined by comparison to published sources of information. When conflicting descriptions of individual earthquakes are found in the published references, the staff should determine which is appropriate for licensing decisions.

2.5.2.2 Geologic and Tectonic Characteristics of Site and Region. For the CEUS sites, when the SSE is determined using the results of the Lawrence Livermore National Laboratory (LLNL) or Electric Power Research Institute (EPRI) probabilistic seismic hazard analysis (PSHA) methodology and data base, and Regulatory Guide 1.165 (Ref. 9) in meeting the requirements of References 1 - 3, this subsection is acceptable when adequate information is provided to demonstrate: (1) that a thorough investigation has been conducted to identify seismic sources that could be significant in estimating the seismic hazards of the region if they exist; and (2) that existing sources (in the PSHA) are consistent with the results of site and regional investigations or the sources have been updated in accordance with Appendix E of Regulatory Guide 1.165.

For sites where LLNL or EPRI methods and data base have not been used, and it is necessary to identify and characterize seismic sources in meeting the requirements of References 1 through 3, adequate information must be provided in this subsection to demonstrate that all seismic sources that are significant in determining the earthquake potential of the region have been identified, or that an adequate investigation has been carried out to provide reasonable assurance that there are no unidentified significant seismic sources.

Information presented in Section 2.5.1 of the applicant's safety analysis report (SAR) or early site evaluation report (ESR) and information from other sources dealing with the current tectonic regime should be developed into a coherent, well-documented discussion to be used as the basis for characterizing the earthquake-generating potential of seismic sources. Specifically, each seismic source, any part of which is within 320 km (200 miles) of the site, must be identified. In the CEUS, the seismic sources will most likely be seismogenic sources with large regions of diffuse seismicity, each characterized by its own recurrence model (more specifically referred to as seismotectonic provinces). The staff interprets seismotectonic provinces to be regions of assumed uniform seismicity (same frequency of occurrence) distinct from the seismicity of the surrounding area. The proposed seismotectonic provinces may be based on seismicity studies, differences in geologic history, differences in the current tectonic regime, or other tectonic considerations.

The staff considers that the most important factors for the determination of seismic sources include both (1) development and characteristics of the current tectonic regime of the region that is most likely reflected in the Quaternary period (approximately the last 2 million years and younger geologic history) and (2) the pattern and level of historical seismicity. Those characteristics of geologic structure, tectonic history, present and past stress regimes, and seismicity that distinguish the various seismic sources and the particular areas within those sources where historical earthquakes have occurred should be described. Alternative regional tectonic models derived from available literature should be discussed. The model that best conforms to the observed data is accepted. In addition, in those areas where there are capable tectonic sources, the results of the additional investigative requirements described in SRP Section 2.5.1 must be presented. The discussion should be augmented by a regional-scale map showing the seismic sources, earthquake epicenters, locations of geologic structures, and other features that characterize the seismic sources.

2.5.2.3 Correlation of Earthquake Activity with Seismic Sources. To meet the requirements in Reference 1, acceptance of this subsection is based on the development of the relationship between the history of earthquake activity and seismic sources of a region. For the CEUS sites, when the SSE is determined using LLNL or EPRI PSHA methodology and data base, and Regulatory Guide 1.165 (Ref. 9) in meeting the requirements of Reference 1, this subsection is acceptable when adequate information is provided to demonstrate (1) that a thorough investigation has been conducted to assess the seismicity and identify seismic sources that could be significant in estimating the seismic hazards of the region if they exist, and (2) that existing sources (in the PSHA) are consistent with the results of site and regional investigations or the sources have been updated in accordance with the Appendix E of Regulatory Guide 1.165.

For sites where LLNL or EPRI methods and data bases are not used and it is necessary to identify and characterize seismic sources in meeting the requirements of Reference 1, adequate information must be provided in this subsection to demonstrate that all seismic sources that are significant in determining the earthquake potential of the region have been identified, or that an adequate investigation has been carried out to provide reasonable assurance that there are no unidentified significant seismic sources.

The applicant's presentation is accepted when the earthquakes discussed in Subsection 2.5.2.1 of the SAR are shown to be associated with seismic sources. Whenever an earthquake hypocenter or concentration of earthquake hypocenters can be reasonably correlated with geologic structures, the rationale for the association should be developed considering the characteristics of the geologic structure (including geologic and geophysical data, seismicity, and the tectonic history) and the regional tectonic model. The discussion should include identification of the methods used to locate the earthquake hypocenters, an estimation of their accuracy, and a detailed account that compares and contrasts the geologic structure involved in the earthquake activity with other areas within the seismotectonic province. Particular attention should be given to determining the recency and level of activity of faults with which instrumentally located earthquake hypocenters may be associated. Acceptance of the proposed seismic sources (those identified by the investigations) is based on the staff's independent review of the geologic and seismic information presented by the applicant and available in the scientific literature.

2.5.2.4 Probabilistic Seismic Hazard Analysis and Controlling Earthquakes. For the CEUS sites relying on LLNL or EPRI methods and data bases, the staff will review the applicant's PSHA, including the underlying assumptions and how the results of the site investigations are used to update the existing sources in the PSHA, how they are used to develop additional sources, or how they are used to develop a new data base.

The staff will review the controlling earthquakes and associated ground motions at the site derived from the applicant's PSHA to be sure that they are consistent with the controlling earthquakes and ground motions used in licensing (a) other licensed facilities at the site, (b) nearby plants, or (c) plants licensed in similar seismogenic regions, or to be sure the reasons they are not consistent are understood. For the CEUS, a comparison of the PSHA results can be made with the information included as Table 1, which is a very general representation based on technical information developed over the past two decades of licensing nuclear power plants.

Table 1

Magnitudes and Distances Within Seismogenic Source Regions of the CEUS Used to Estimate the SSE

SEISMIC SOURCES	MAGNITUDE	DISTANCE TO SITE (KM)
Northern New England	5.8 mb	15
Piedmont - New England	5.6 mb	15
Southern Valley and Ridge	5.7 mb	15
Atlantic Coastal Plain	5.5 mb	15
Gulf Coast	5.4 mb	15
Central Stable Region	5.5 mb	15
Charleston	7.5 Ms	Site-specific
New Madrid	8.5 Ms	Site-specific

The applicant's probabilistic analysis, including the derivation of controlling earthquakes, is considered acceptable if it follows the procedures in Regulatory Guide 1.165 and its Appendix C (Ref. 9). Incorporating the results of site investigations into the probabilistic analysis is considered acceptable if it follows the procedure outlined in Appendix E of Regulatory Guide 1.165 and is consistent with the review findings of Sections 2.5.2.2 and 2.5.2.3.

In addition to the above reviews for CEUS sites where applicants did not use the LLNL or EPRI methods and data bases, the staff will further review the applicant's PSHA or other method used to derive controlling earthquakes. The staff will particularly review the approaches used to address uncertainties. The staff will perform an independent evaluation of the earthquake potential associated with each seismic source that could affect the site. The staff will evaluate the applicant's controlling earthquakes using historical seismicity (including maximum historical earthquakes) and paleoseismicity.

For sites not in the CEUS, the staff will review the PSHA or other methods in detail. As in the reviews of CEUS sites, the staff will particularly review the approaches used to address uncertainties. The staff will assess the controlling earthquakes for the site derived from the applicant's method to be sure that they are consistent with the controlling earthquakes and ground motions used in licensing (a) other licensed facilities at the site, (b) nearby plants, or (c) plants licensed in similar seismogenic regions, or to be sure the reasons they are not consistent are understood.

The determination of the controlling earthquakes and the seismic hazard information base for sites not in the CEUS is carried out using procedures similar to those used for CEUS. However, because of differences in seismicity rates and ground motion attenuation characteristics at these sites, alternative magnitude-distance parameters may have to be used. In addition, an alternative reference probability may also have to be developed, particularly for sites in the active plate margin region and for sites at which a known tectonic structure dominates the hazard. The staff will perform an independent evaluation of the earthquake potential associated with each seismic source that could affect the site. The staff will evaluate the applicant's controlling earthquakes based on historical seismicity (including maximum historical earthquakes) and paleoseismicity.

For guidance in evaluating the earthquake potential and characterizing the uncertainty for sites that are assessed using methods other than the LLNL or EPRI methods and data bases, or for sites outside the CEUS, refer to the Senior Seismic Hazard Analysis Committee (SSHAC) Report (Ref. 12).

<u>2.5.2.5 Seismic Wave Transmission Characteristics of the Site</u>. In the PSHA procedure described in Regulatory Guide 1.165 (Ref. 9), the controlling earthquakes are determined for actual or hypothetical rock conditions. The site amplification studies are performed in a distinct separate step as a part of the determination of the SSE. In this section, the applicant's site amplification studies are reviewed in conjunction with the geotechnical and structural engineering reviews. Particular emphasis is placed on how the uncertainties inherent in this process are addressed.

To be acceptable, the seismic wave transmission characteristics (amplification or deamplification) of the materials overlying bedrock at the site are described as a function of the significant frequencies (Ref. 13). The following material properties should be determined for each stratum under the site: thickness, seismic compressional and shear wave velocities, bulk densities, soil index properties and classification, shear modulus and damping variations with strain level, and the water table elevation and its variations (Ref. 14). In each case, methods used to determine the properties should be described in Subsection 2.5.4 of the SAR and cross-referenced in this subsection.

Where vertically propagating shear waves may produce the maximum ground motion, a one-dimensional equivalent-linear analysis (e.g., Ref. 15 or 16) or nonlinear analysis (e.g., Refs. 17, 18, or 19) may be appropriate and is reviewed in conjunction with geotechnical and structural engineering. Where horizontally propagating shear waves, compressional waves, or surface waves may produce the maximum ground motion, other methods of analysis (e.g., Refs. 20 and 21) may be more appropriate. However, since some of the variables are not well defined and the techniques are still in the developmental stage, no generally agreed-upon procedures can be promulgated at this time. Hence, the staff must use discretion in reviewing any method of analysis. To ensure appropriateness, site response characteristics determined from analytical procedures should be compared with historical and instrumental earthquake data, when available.

<u>2.5.2.6 Safe Shutdown Earthquake Ground Motion</u>. In this subsection, the staff reviews the applicant's procedure to determine the SSE, including the procedure used to derive spectral shape from the controlling earthquakes as described in Reference 9.

As a part of the review of the adequacy of the SSE proposed by the applicant, the staff performs an independent evaluation of ground motion estimates, as required.

The following procedures (in descending order of preference) should be used to develop the site-specific spectral shapes for controlling earthquakes. These procedures are also used to make ground motion estimates when the probabilistic methods are not used. In the following procedures, 84th percentile response spectra are used for both spectral shape and ground motion amplitude estimates.

1. Both horizontal and vertical component site-specific response spectra should be developed statistically from response spectra of recorded strong motion records that are selected because they have similar sources, propagation paths, and recording site properties as the controlling earthquakes. It must be ensured that the recorded motions represent free-field conditions and are free of or corrected for any soil-structure interaction effects that may be present because of locations or housing of recording instruments. Important source properties include magnitude and, if possible, fault type and tectonic environment. Propagation path properties include distance, depth, and attenuation. Relevant site properties include shear wave velocity profile and other factors that affect the amplitude of waves at different frequencies. A sufficiently large number of site-specific time-histories or response spectra or both should be used to obtain an adequate broadband spectrum to encompass the uncertainties in these parameters. An 84th percentile response spectrum for the records should be presented for each damping value of interest (e.g., Refs. 22--25). The staff considers direct estimates of spectral ordinates preferable to scaling of spectra to peak accelerations. If the data for site-specific response spectra were not obtained under geologic conditions similar to those at the site, corrections for site effects should be included in the development of the site-specific spectra.

2. Where a large enough ensemble of strong-motion records is not available, response spectra may be approximated by scaling that ensemble of strong-motion data that represent the best estimate of source, propagation path, and site properties (e.g., Ref. 26). Sensitivity studies should show the effects of scaling.

3. If strong-motion records are not available, site-specific peak ground acceleration, velocity, and displacement (if necessary) should be determined for appropriate magnitude, distance, and foundation conditions. Then response spectra may be determined by scaling the acceleration, velocity, and displacement values by appropriate amplification factors (e.g., Ref. 27). For each controlling earthquake, the peak ground motions should be determined using current relations between

acceleration, velocity, and, if necessary, displacement, earthquake size (magnitude or intensity), and source distance. Peak ground motion should be determined from state-of-the-art relationships. Relationships between magnitude and ground motion are found, for example, in References 13 and 28. Because of the limited data for high intensities greater than MMI VIII, the available empirical relationships between intensity and peak ground motion may not be suitable for determining the appropriate reference acceleration for seismic design.

4. Spectra developed by theoretical-empirical modeling of ground motion may be used to supplement site-specific spectra if the input parameters and the appropriateness of the model are thoroughly documented (e.g., Refs. 13, 28, and 29). Modeling is particularly useful for sites near seismic sources that may experience ground motion that is different in terms of frequency content and wave type from ground motion caused by more distant earthquakes.

The SSE response spectra proposed by the applicant are considered acceptable if they meet Regulatory Position 4 and Appendix F of Reference 9. If the independent staff estimates of ground motion are significantly different from those proposed by the applicant, the staff will review the reasons for differences and resolve them as appropriate.

The time duration and number of cycles of strong ground motion are required for analysis and design of many plant components. The adequacy of the time history for structural analysis is reviewed under SRP Section 3.7.1. The time history is reviewed in this SRP section to confirm that it is compatible with the seismological and geological conditions in the site vicinity and with the accepted SSE model. At present, models for computing the time history of strong ground motion from a given source-site configuration are limited. Total duration of the motion is acceptable when it is as conservative as values determined using current studies such as References 30 - 33.

For evaluation of the liquefaction potential at the site, the time duration and number of cycles of strong ground motion are critical parameters and require additional consideration. If the controlling earthquakes for the site have magnitudes of less than 6, the time history selected for the evaluation of liquefaction potential must have duration and number of strong motion cycles corresponding to at least an event of magnitude 6.

III. REVIEW PROCEDURES

Upon receiving the applicant's SAR or ESR, an acceptance review is conducted to determine compliance with the investigative requirements of 10 CFR Section 100.23 (Ref. 1). The reviewer also identifies any site-specific problems, the resolution of which could result in extended delays in completing the review.

After SAR or ESR acceptance and docketing, the reviewer identifies areas that need additional information to support the review of the applicant's seismic design. These are transmitted to the applicant as requests for additional information.

A site visit may be conducted, during which the reviewer inspects the geologic conditions at the site and the region around the site as shown in outcrops, borings, geophysical data, trenches, and those geologic conditions exposed during construction. The reviewer also discusses the questions with the applicant and his consultants so that it is clearly understood what additional information is required by the staff to continue the review.

The reviewer evaluates the applicant's response to the questions, prepares requests for any additional information, and formulates positions that may agree or disagree with those of the applicant. These are formally transmitted to the applicant.

The SAR or ESR and amendments responding to the requests for additional information are reviewed to determine that the information presented by the applicant is acceptable according to the criteria described in Section II (Acceptance Criteria) above. Based on information supplied by the applicant and information obtained from site visits, staff consultants, or literature sources, the reviewer independently identifies and evaluates the relevant seismic sources, including their capability, and determines the earthquake potential for each using procedures noted in Section II, Acceptance Criteria, above. The reviewer evaluates the vibratory ground motion that the controlling earthquakes could produce at the site and compares that ground motion to the SSE used for design.

IV. EVALUATION FINDINGS

On completion of the review of the geologic and seismologic aspects of the plant site, if the evaluation by the staff confirms that the applicant has met the requirements or guidance of applicable portions of References 1 through 6 and 9, the conclusion in the Safety Evaluation Report (SER) states that the information provided and investigations performed support the applicant's conclusions regarding the seismic characterization of the subject nuclear power plant site. In addition to the conclusion, this section of the SER includes an evaluation of (1) seismic sources, (2) the capability of geologic structures in the region, (3) controlling earthquakes and associated free-field response spectra, (4) the SSE, and (5) the time history of strong ground motion. Staff reservations about any significant deficiency presented in the applicant's SAR are stated in sufficient detail to make clear the precise nature of the concern. In addition, the staff will also note the results of its independent analyses, if performed, and discuss how these results were used in the safety evaluation. The above evaluations are made by the staff during the construction permit (CP), operating license (OL), combined license (COL), or early site permit phases of review as appropriate.

OL and COL applications are reviewed for any new information developed subsequent to the CP SER or the early site evaluation. The review will also determine whether the recommendations made following the CP or early site review have been implemented.

A typical COL or OL-stage summary finding for this section of the SER follows:

> In our review of the seismologic aspects of the plant site, we have considered pertinent information gathered since our initial seismologic review that was made in conjunction with an early site review or the issuance of the CP. This new information includes data gained from both site and near-site investigations as well as from a review of recently published literature.

As a result of our recent review of the seismologic information, we have determined that our earlier conclusion regarding the safety of the plant from a seismological standpoint remains valid. These conclusions can be summarized as follows:

1. Seismologic information provided by the applicant and required by 10 CFR 100.23 provides an adequate basis to establish that no seismic sources exist in the plant site area that would cause earthquakes to be centered there.

2. The response spectrum proposed for the SSE is the appropriate free-field response spectrum in conformance with 10 CFR 100.23.

The new information reviewed for the proposed nuclear power plant is discussed in SER Section 2.5.2.

The staff concludes that the site is acceptable from a seismologic standpoint and meets the requirements of (1) General Design Criterion 2 in Appendix A to 10 CFR Part 50, (2) 10 CFR Part 100, and (3) 10 CFR 100.23. This conclusion is based on the following:

1. The applicant has met the requirements of:

    a. General Design Criterion 2 in Appendix A to 10 CFR Part 50, with respect to protection against natural phenomena such as faulting.

    b. 10 CFR Part 100, "Reactor Site Criteria," with respect to the identification of geologic and seismic information used in determining the suitability of the site.

    c. 10 CFR 100.23 (Ref. 1) with respect to obtaining the geologic and seismic information necessary to determine (1) site suitability and (2) the appropriate design of the plant. Guidance for complying with this regulation is contained in Regulatory Guide 1.132, "Site Investigations for Foundations of Nuclear Power Plants" (Ref. 4); Regulatory Guide 1.165, "Identification and Characterization of Seismic Sources and Safe Shutdown Earthquake Ground Motion" (Ref. 9); and Regulatory Guide 4.7, "General Site Suitability Criteria for Nuclear Power Stations" (Ref. 5).

V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using this SRP section.

Except in those cases in which the applicant or licensee proposes an acceptable alternative method for complying with specific portions of the Commission's regulations, the methods described herein will be used by the staff in its evaluation of conformance with NRC's regulations.

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guides and NUREGs (Refs. 4 through 9).

The provisions of this SRP section apply to reviews of construction permits, operating licenses, early site permits, and combined license applications docketed pursuant to 10 CFR 100.23.

VI. REFERENCES

1. Section 100.23, "Geologic and Seismic Siting Factors," of 10 CFR Part 100, "Reactor Site Criteria."
2. General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena," in Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities."
3. 10 CFR Part 100, "Reactor Site Criteria."
4. USNRC, "Site Investigations for Foundations of Nuclear Power Plants," Regulatory Guide 1.132.[1]
5. USNRC, "General Site Suitability Criteria for Nuclear Power Stations," Regulatory Guide 4.7.[1]
6. USNRC, "Design Response Spectra for Seismic Design of Nuclear Power Plants," Regulatory Guide 1.60.[1]
7. USNRC, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants (LWR Edition)," Regulatory Guide 1.70.[2]
8. USNRC, "Report of the Siting Policy Task Force," NUREG-0625, August 1979.[2]
9. USNRC, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion," Regulatory Guide 1.165.[1]
10. R. L. Street and F. T. Turcotte, "A Study of Northeastern North American Spectral Moments, Magnitudes, and Intensities," Bulletin of the Seismological Society of America, Vol. 67, pp. 599-614, 1977.

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[1]Single copies of the regulatory guides, both active and draft, may be obtained free of charge by writing the Office of Administration, Attn: Distribution and Services Section, USNRC, Washington, DC 20555 or by fax at (301)415-2260. Copies are available for inspection or copying for a fee from the NRC Public Document Room at 2120 L Street NW., Washington, DC; the PDR's mailing address is Mail Stop LL-6, Washington, DC 20555; telephone (202)634-3273; fax (202)634-3343.

[2]Copies are available for inspection or copying for a fee from the NRC Public Document Room at 2120 L Street NW., Washington, DC; the PDR's mailing address is Mail Stop LL-6, Washington, DC 20555; telephone (202)634-3273; fax (202)634-3343. Copies may be purchased at current rates from the U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20402-9328 (telephone (202)512-2249); or from the National Technical Information Service by writing NTIS at 5285 Port Royal Road, Springfield, VA 22161.

11. O. W. Nuttli, G. A. Bollinger, and D. W. Griffiths, "On the Relation Between Modified Mercalli Intensity and Body-Wave Magnitude," Bulletin of the Seismological Society of America, Vol. 69, pp. 893-909, 1979.

12. Senior Seismic Hazard Analysis Committee (SSHAC), "Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts," Lawrence Livermore National Laboratory, UCRL-ID-122160, August 1995 (to be published as NUREG/CR-6372).

13. Electric Power Research Institute, "Guidelines for Determining Design Basis Ground Motions," EPRI Report TR-102293, Vols. 1-4, May 1993.

14. USNRC, "Laboratory Investigations of Soils for Engineering Analysis and Design of Nuclear Power Plants," Regulatory Guide 1.138.[1]

15. P. B. Schnabel, J. Lysmer, and H. B. Seed, "SHAKE-A Computer Program for Earthquake Response Analysis of Horizontally Layered Sites," Report No. EERC 72-12, Earthquake Engineering Research Center, University of California, Berkeley, 1972.

16. E. Faccioli and J. Ramirez, "Earthquake Response of Nonlinear Hysteretic Soil Systems," International Journal of Earthquake Engineering and Structural Dynamics, Vol. 4, pp. 261-276, 1976.

17. I. V. Constantopoulos, "Amplification Studies for a Nonlinear Hysteretic Soil Model," Report No. R73-46, Department of Civil Engineering, Massachusetts Institute of Technology, 1973.

18. V. L. Streeter, E. B. Wylie, and F. E. Richart, "Soil Motion Computation by Characteristics Methods," Proceedings of the American Society of Civil Engineers, Journal of the Geotechnical Engineering Division, Vol. 100, pp. 247-263, 1974.

19. W. B. Joyner and A. T. F. Chen, "Calculations of Nonlinear Ground Response in Earthquakes," Bulletin of the Seismological Society of America, Vol. 65, pp. 1315-1336, 1975.

20. T. Udaka, J. Lysmer, and H. B. Seed, "Dynamic Response of Horizontally Layered Systems Subjected to Traveling Seismic Waves," Proceedings of the Second U.S. National Conference on Earthquake Engineering, 1979.

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